Analysis of Some Inventory Model with Time Dependent Demand

Synopsis submitted to IIMT University in partial fulfilment of the requirement for the award of the degree of

DOCTOR OF PHILOSOPHY

In

MATHEMATICS

By

PRASHANT SHARMA

Full Time

Under The Guidance Of

Dr. Birendra Kumar Chauhan

School Of Basic Science & Technology

IIMT University, Meerut

IIMT UNIVERSITY, MEERUT

Department of Mathematics

School of Basic Science & Technology,

IIMT UNIVERSITY, MEERUT

September 2022

INTRODUCTION

The categorization of shortages in inventory management. It's true that inventory levels are often determined by demand patterns, and when the demand exceeds the available inventory, shortages can occur. These shortages can be classified into two main categories: backorders (or

backlogging) and lost sales. inventory levels to minimize shortages and strike a balance between backlogging and lost sales, depending on the nature of the product and customer expectations.

1. Backorder/Backlogging: In this case, when a customer wants to purchase a product that is currently out of stock, they may choose to wait for the item to become available again. The customer relies on the retailer or shopkeeper to fulfill their demand as soon as possible. This situation allows for partial backlogging, meaning the demand is not immediately fulfilled, but the customer is willing to wait for a certain period.
2. Lost Sales: In the case of lost sales, the demand for a product exceeds the available inventory, but the customer is unwilling or unable to wait for the item to be restocked. As a result, the sale is lost because the customer seeks alternative sources to fulfill their immediate need.

The inventory models progress under the expectation of lifetime of results is infinite until its repository. An item once put away in a store space area remains unchanged and fully generally for rewarding future stipulation however in actuality it is not true due to the out- comes of deterioration in care of regularly used mundanely commodities like weats or any other type of commodities grains milk fruits.

With increasing concerns about the natural environment and sustainability, the development of sustainable inventory management practices for perishable items has indeed become a significant research area. Perishable items such as food, vegetables, meat, dairy products, and other deteriorating resources present unique challenges in terms of inventory management.

A comprehensive description of inventory and the importance of proper inventory management. Indeed, inventory refers to the usable resources of products that are available for future use within their utility durations. Managing inventory effectively involves considering factors such as expected demand, raw material requirements for finished items, the cost of carrying inventory, potential damage during storage, and the devaluation of stock, all of which can significantly impact a company's profitability.Proper inventory management is crucial for enterprises as it ensures that the attribute and utility of products are preserved. It is of great interest to suppliers, manufacturers, and retailers alike. Failure to manage inventory effectively can result in the loss of value over time, decay, damage, vaporization, or complete loss of utility. This is particularly true for perishable items such as fruits, vegetables, and other food commodities, which are prone to direct spoilage. Inadequate storage conditions and risks from pests like rats and cats can further contribute to the deterioration of these perishable goods.

The classical inventory models often assume demand to be either constant or time-dependent. The classical economic order quantity (EOQ) model, developed in 1915, is one such example. Over time, various inventory models have been developed in the literature, primarily considering constant demand patterns.However, in the real market, demand for many products exhibits time-dependent, price-dependent, or stock-dependent characteristics. This means that demand can

vary based on factors such as seasonality, promotional activities, price fluctuations, and the availability of stock.

Deterioration refers to the process of change, damage, decay, spoilage, evaporation, obsolescence, pilferage, or any other factors that result in a decrease in the usefulness or marginal value of a commodity. It signifies a decline in the quality, effectiveness, or utility of a product from its original state. Many products have a finite shelf life and begin to deteriorate once they are replenished or produced.

In symmetrical inventory models, the depletion or consumption of inventory is indeed typically assumed to be caused by a constant demand rate. These models are often applied in buyer-seller situations, where one party (the buyer) regularly places orders to replenish their inventory from another party (the seller).The buyer's inventory level is monitored, and when it reaches a certain reorder point or threshold, a new order is placed with the seller to replenish the inventory. The demand rate is assumed to be constant, meaning that the buyer requires a fixed quantity of items per unit of time.

In the past few decades, there has been significant interest in developing mathematical models that consider the presence of trade credit in business transactions. Trade credit refers to the practice where buyers are allowed a certain period of time, known as the credit period, before they are required to settle their account with the seller.Trade credit is a common practice in today's business transactions, and it plays a crucial role in managing cash flow and facilitating business operations. The extension of trade credit allows buyers to defer payment and provides them with more flexibility in managing their working capital. Sellers, on the other hand, use trade credit as a competitive tool to attract customers and maintain ongoing business relationships.

Managing deteriorating item inventory can be challenging in real-life situations. Deterioration of items can have a significant impact on costs and the overall efficiency of the system. When items deteriorate over time, a fraction of the inventory may become damaged, spoiled, or unsuitable for future use, resulting in a loss of value and utility. The loss due to deterioration should not be neglected, as it directly affects the profitability and effectiveness of the inventory management system.

Inaccurate forecasting of customer demand can lead to losses for the trader, particularly when it comes to the end of a product's life cycle. When inventory is not properly aligned with market demand, its value can significantly diminish, resulting in financial losses for the business.To mitigate these risks and maintain cost-effective inventory management, businesses can adopt several strategies. By implementing the strategies, businesses can minimize the financial impact of inaccurate demand forecasting and optimize inventory management. This leads to reduced costs, increased profitability, and improved utilization of resources within the industry.

CONCEPTION OF INVENTORY

Inventory or capital mention to the commodities and materials that a occupation holds for the benefit goal of re-production or utilisation. Inventory management is a regulation first and more most about describe the shape and placement of keep in stock goods. It is appeal at distinct locations within a solution or within many position of a supply system to precede the systematic and design course of manufacture and goods of materials.

The conception of inventory, goods work in progression has been put out from construct structure to assistance occupation and estimate, by conception the definition to be "All work in the procedure of making - all exertion that is or has take place prior to the realization of production". In the conditions of a construct production order, inventory mention to all efforts that has occurred – basic materials, partially conclude products, finished products prior to sale and going away from the constructed system. In the state of affairs of services, inventory refers to all assignment prior to sale, including partially procedure information.

So for an enterprise an inventory of materials becomes essential in order to:-

1. Effectual use of capital
2. Systematic running of business
3. Economic service to purchaser

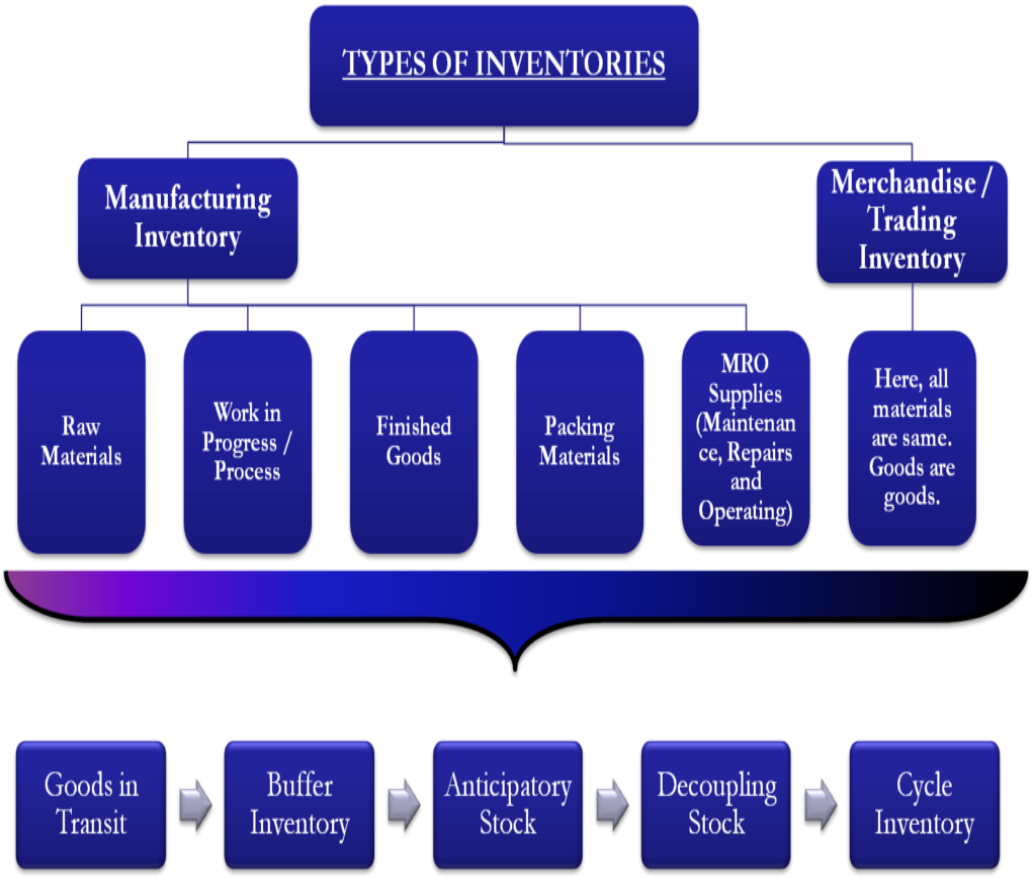
Inventory refers to the stock of products that a business maintains, including raw materials, work-in-process items, finished goods, and spare parts. The purpose of maintaining inventory is to reduce costs associated with ordering and penalties. Inventory helps businesses meet customer demand promptly and avoids disruptions in the production or distribution process. Inventory incurs various costs, including setup or ordering costs, holding or carrying costs, opportunity costs, and storage costs. By carefully managing inventory, businesses aim to minimize these costs while ensuring the availability of goods when needed.Inventory models are crucial for industries involved in manufacturing, distribution, and retail, as they help determine the optimal inventory strategy. However, when it comes to demand forecasting, classical inventory models often assume constant demand. While this assumption may be effective during a specific period in the product's life cycle, it may not hold true throughout the entire life cycle.

TYPES OF INVENTORY

There are five types of inventory.

1. **FUCTUATION INVENTORY:** It is produced to research any emergency of stock.
2. **ANTICIPATIONINVENTORY:** The Anticipation Inventory is designed to ensure that no customer is left dissatisfied by not receiving the necessary items.
3. **TRANSPORTATION INVENTORY:**Transportation Inventory plays a vital role in the shipment of products from one location to another and ultimately to consumers. It involves managing and tracking inventory during the transportation process to ensure the timely and efficient delivery of goods.

4. **CYCLE INVENTORY**: Cycle Inventory refers to the inventory that fluctuates in a cyclical pattern based on the rate of consumption and production purchasing. It represents the regular inventory replenishment cycle that occurs as a result of periodic orders placed by a business to replenish its stock.
5. **DECOUPLING INVENTORY:** Decoupling Inventory is a type of inventory that is held as a precautionary measure to decouple or separate different stages of production or supply chain processes. It serves as a cushion to absorb uncertainties and variations in demand, supply, or lead times, ensuring smooth operations and minimizing disruptions.



SURVEY

Managing and maintaining inventory of deteriorating products poses a unique challenge for businesses. Traditional inventory models often assume that products remain in their original condition until they are sold, which is not always the case for items that are subject to decay, damage, obsolescence, or other forms of deterioration. To address this issue, businesses can implement specialized inventory models designed specifically for deteriorating products. These models take into account factors such as shelf life, expiration dates, and the rate of deterioration.

Classical deterministic inventory models often assume certain demand patterns, such as constant, stock-dependent, or time-dependent demand rates. Additionally, changes in product price can indeed have an impact on demand and, consequently, inventory management strategies.When prices decrease, it can stimulate demand and potentially lead to increased sales. This presents an opportunity for businesses to adjust their inventory management strategies to maintain economic efficiency.

Operations research, also known as operational research or simply OR, is a discipline that applies scientific and mathematical methods to solve complex problems related to decision-making and operations within organizations. It involves using analytical models, optimization techniques, and computational tools to help decision-makers make informed choices and improve overall efficiency.

When designing a model in operations research, there are typically two primary goals to consider:

1. Realizability: The model should be as close to reality as possible. It should accurately represent the problem, its constraints, and the relationships between various variables and parameters. The model should capture the key aspects of the problem under consideration to provide meaningful insights and support decision-making. Realizability ensures that the model reflects the complexities and intricacies of the real-world system, enabling decision-makers to make informed choices.
2. Feasibility: The model should be practical and solvable. It should strike a balance between complexity and simplicity. While it's important to capture the essential details of the problem, overly complex models can become difficult to solve or analyze. A model that is too complex may require excessive computational resources, time, or data, making it impractical to implement. Therefore, simplicity is desirable in terms of the model's structure, assumptions, and variables to ensure that it remains manageable and produces actionable results.

The first ego inventory model was developed by harries [1915] which was further generalized by Wilson [1934] to obtain formula for profitable order amount. Within [1957] studied the deterioration of the fashion goods at the end of the prescribed shortage period. glare and Schrader [1963] developed a model for an exponentially decaying inventory. Moving further, firstly Dave and Patel [1981] have studied a linear increasing deteriorating inventory when shortages are not permitted. Advance work in this area has been made via. Chung and Ting [1993]; and wee[1995] established an inventory model amid deteriorating items. Chang and dye [1999] worked on an inventory model amid partial backlogging and time-varying demand.

V. K. Mishra and L. S. singh [2010] developed in deteriorating inventory model amid partial backlogging and time dependent demand. V. K. Mishra [2012] and L. S. Singh, R. kumar [2013] examined an inventory model for time dependent holding cost and deterioration with shortages and salvage value. D. Dutta, P. Kumar [2015] established a partial backlogging model for deteriorating items amid holding cost and time varying. A deterministic inventory model together with quadratic holding cost, selling price, quadratic time varying deteriorating rate and dependent demand rate, has developed by V. Sharma and A. K. Sharma [2015]. S. Kumar and R. Kumar [2015] studied a deterministic model for unpreserved items with shortages and time dependent demand. R.P Tripathi and H.S. Pandey [2015] described an inventory model together with time dependent demand rate and totally backlogged acceptable hold-up in payments. S. kumar [2016] studied deteriorating item optimization's inventory model together with price and time dependent demand. N. A. Khan, V.S. Verma, V. Kumar [2017] have studied an inventory model for comparts deteriorating items together with price dependent demand and time varying cost. S. Kumar [2017] established a model with time varying cost, exponential decreasing demand and steady deterioration. Vandana [2018] has developed a model with demand rate partial and complete backlogging and time-dependent deterioration. N. Kumar, D. Yadav and R. kumari (2018) have studied two level production inventory model together with exponential dependent and time dependent deterioration rate. Shah [2018] has studied inventory management with time dependent deteriorating items together with salvage value. R. B. Krishna Raj & K. Ramayana (2018) developed a model for weibull time dependent require rate with totally backlogged. R.P Tripathi, D.Singh and S. Aneja [2018] have established models for stock-dependent require and time varying cost under diverse trade credits. R.K. Priya and K. Senbagam [2019] studied model for partial backlogging, quadratic time varying demand variable deterioration with time dependent deteriorating products. A. Kumar, S. K. Paikray and U. Mishra [2020] have developed two storage fuzzy inventory models together with holding cost and time dependent demand under suitable delay in payment. P. Sharma, S. Sharma, B.V. Singh, A. Tyagi [2020] have studied affect of inflation on two storage space inventory model together with time dependent and stock dependent demand. Kusum and V. Kumar [2021] have studied a model for deterministic inventory together with deteriorating items and demand dependent on time fractionally and cost deterioration rate and steady holding. C.K Sivanshankari and L. Ramchandran [2022] have established inventory models together with integrated time dependent required for deteriorating items. Y. Ibrahim and V. V. Singh [2022] have established ameliorating inventory model with partial backlogging rate and time dependent demand.

PROPOSED STUDY

The research is to grow some mathematical version in sequence to keep down the annual total costly of inventory. Researcher dealt with an inventory version for deteriorating items with wears

with respect to price, learning effect and affectation. The emergence of this representation is the difficulty of a medicine supermarket for whom the above as his occupation constrains.

OBJECTIVES

1. To be survey of inventory representation for deteriorated items with stock with respect to price and demand.
2. To be survey of manufacture inventory representation with stock with respect to price and price shortages under inflationary environment.
3. To be survey of inventory representation for deteriorated product with aggressive demand under trade credit.
4. To be survey of inventory representation with stock and selling price dependent price rate, partial backlogging and variable ordering cost.
5. To be survey of inventory product for non rapid deteriorating products with selling price dependent price rate under learning effect.

METHODOLOGY

1. Literature survey.
2. Model development.
3. Development of computer programs.
4. Real time simulation of models developed.
5. Interpretations of the results.
6. Publication of the technical papers.
7. Compilation of the final results, theories developed \evolved and preparation of the thesis.

REFERENCES

1. V. K. Mishra and L. S. singh [2010] "Deteriorating inventory model with time dependent demand and partial backlogging", Applied Mathematical Science, vol 4,p.p 3611-3619
2. V. K. Mishra [2012]" Inventory model for time dependent holding cost and deteroration with salvage value and shortages", International Journal for Research, vol 9, p.p – 296-301.
3. V. K. Mishra, L. S. Singh, and R. kumar [2013]" An inventory model for deteriorating items with time – dependent demand and time varing holding cost under partial backlogging", Journal of Industrial Engineering International vol. 9(4), p.p 2-5.
4. V.K. Mishra [2014]"Control deterioration rate for time dependent demand and time – varying holding cost", Yugoslav Journal of Operation Research, vol 24(1), p.p 87-98.
5. D. Dutta, and P. Kumar [2015], "A partial backlogging inventory model for deteriorating items with time varying and holding cost: an interval number approach", International Journal of Mathematics in Operation Research , vol 7 p.p – 281-286.
6. S. Sharma, and A. K. Sharma [2015] "A deterministic inventory model with selling price dependent demand rate, quadratic holding cost and quadratic time varying deteriorating rate", Amity University, vol 4 , p.p – 85-90
7. S. Kumar and R. Kumar [2015] "A deterministic inventory model for perishable item with time dependent demand and shortages", International Journal of Mathematics and Its Application, vol 4, p.p – 105-111
8. S. Kumar [2016] "Optimization of deteriorating item inventory model with price and time dependent demand", Amity Journal of Operation Management, vol 4, p.p 38-54
9. N. A. Khan, V.S. Verma, and V. Kumar [2017] "An inventory model for comparts deteriorating items with time varyingholding cost and price dependent demand", International Journal for Mathematics, vol 49
10. Dr. S. Kumar [2017] "An inventory model with time varying holding cost, exponential decaying demand and constant deterioration" A Peer Reviewed Refereed International Research Journal, vol 1 ,p.p – 01-09,
11. Vinod. [2018] "An inventory model with time – dependent deterioration and ramp-type demand rate complete and partial backlogging". Applied Mathematical Sciences, Vol. 4, no. 72, 3611 - 3619
12. N. Kumar, D. Yadav and R. kumari [2018] "Two level production inventory model with exponential demand and time depend deterioration rate", Malaya Journal Matematik, vol 1, p.p. 30-34.
13. P. Mishra and N. Shah [2018] "Inventory management of time dependent deteriorating items with salvage value", International Journal of Mathematics, Engineering and Management., vol 5, p.p -544-555
14. R.P. Tripathi, D. Singh and S. Aneja [2018] "Inventory models for stock- dependent demand and time varing holding cost under different trade credits", Yugoslav Journal of Operation Research, vol 28, p.p 139-151,

15. R. Kavitha and K. Senbagam [2019] “Ego inventory model for time dependent deteriorating products with quadratic time varying demand variable deterioration and partita backlogging”, ARPN Journal of Engineering and Applied science, vol 13, p.p -7-15
16. A. Kumar, S. K. Paikray and U. Mishra [2020] “Two – storage fuzzy inventory model with time dependent demand and holding cost under acceptable delay in payment”, Mathematical Modelling and Analysis, vol 25, pp -441-460
17. P Sharma, S Sharma, B.V. and S. A. Tyagi [2020] “Effect of inflation on two storage inventory model with time dependent deteriorating item and stock dependent demand”, International Journal of Mathematics, Engineering and Management., vol 5, p.p -544-555
18. Kusum and V. Kumar [2021] “A model for deterministic inventory with deteriorating items with demand dependent on time fractionally and constant holding and cost deterioration rate”, International Journal of Engineering Research & Technology, vol 10, issn- 2278- 0181
19. Md. Al- Amin khan, Mohd.Abdul Halim and Ali Alarjani,[2021] “ Inventory management with hybrid cash – advance payment for time – dependent demand, time – varying holding cost and non – instantaneous deterioration under backordering and non terminating situation”, Alexaindia Engineering Journal, vol4, p.p – 87- 98
20. C.K. Sivanshankari and L. R. [2022],” Inventory models with integrated time dependent demands for deteriorating items-in third and fourth order”, Ratio Operation Research, vol 55,p.p- 2883-2905.
21. Y. Ibrahim and V. Singh [2022], “Replenishment decision for ameliorating inventory with time dependent demand and partial backlogging rate”, Amity International Journal Manegement , vol 4, p.p 93-102. DOI: 10.1504/IJOR.2020.10034078